

Spiral arms in galaxies **with** two-way **(counter-rotating)** disks

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Recent spectroscopic observations indicate that the S galaxies NGC 4550 and NGC 7217 have two-way disks with a substantial portion of the stellar disk orbiting opposite the direction of the rest. In 1977, Kalnajs found that two-way disks are less susceptible to two-fold bar instabilities even in the absence of any inert stabilizing halo. This raised hopes of a non-halo mechanism to stabilize disks. In 1978, Zang and Hohl found that one-fold instabilities are enhanced in a two-way disk with no halo. Subsequent analytic work confirmed this result. In recent simulations, Sellwood and Merritt find that the one-sided instability is enhanced for Kuz'man/Toomre disks but that a stable halo-less model parameter range does exist. Using a self-gravitating disk with a flat rotation curve, we redo Zang and Hohl's isolated simulations but with more particles and including trials with varying amounts of an inert "halo" component. We confirm their result and find that an inert halo equal to the two-way disk will stabilize against one and two sided disturbances. Since small companions should frequently perturb disk galaxies, we conduct a variety of simulations of the spiral arm patterns created by such passages. In general, tidal spiral arm patterns in two-way disks are more symmetric and smoother than in one-way disks. Galaxies with these disk pattern characteristics may be more likely observational candidates in the search for two-way disks or high halo galaxies. A small companion merging with a two-way disk creates a distinctive one-arm pattern during the merger.